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The Use of Commercial Components in Defense Equipment to Mitigate Obsolescence.
A Contradiction in Itself ?

by

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Abstract:

The paper identifies and discusses the presently unresolved contradictions between the requirements of the national customers (MODs or Purchasing Agencies) and the viable options the industry can offer to mitigate the adverse effects of obsolescence for defense material with emphasis on the extended use of COTS.

Twenty years ago the main technical discussion topic within the defense industry was technological progress and achievements. Today we have become prisoners of this progress and are increasingly unable to keep pace with the technology. Instead we have to deal with the antithesis of progress – outdated or obsolete components. Obsolescence concerns suppliers and customers in different ways but in any case the result is painful since obsolescence has adverse effects on our business. There is no way to defeat obsolescence, it has properties like gravity, it lurks everywhere in our electronics world and it will stay. We have to accept it like a law of physics and as a fact of our professional - and our private - life. When I studied electronics engineering in the sixties, I used to make some money by repairing TV sets. My stock of spares to repair a hundred or even more different sets easily fitted into a briefcase and consisted of some 20 electron tubes and a handful of resistors and capacitors. Have you ever tried to get your 5 year old Korean Video Cassette Recorder repaired? – an ambitious task which will frustrate you quickly and will probably result in the acquisition of a new one for 200 bucks or even less. In

all probability you would not even have tried since you wanted a new one anyway.

Let me get this straight from the very beginning. Obsolescence is a very big problem for the supplier industry. It has not been created by the industry – as some may see it – as a welcomed source for additional revenue.

Aircraft Program Cornerstones

- Start of Development ~1990
- Production Investment 1998
- First Production Aircraft 2001
- Last Production A/C 2015 ?
- End of useful life 2050 ??

Average Introduction Rate For New Generations of Commercial Integrated Circuits

LOGIC FAMILIES . . . . 6 YRS
MEMORY FAMILIES . . . . 9 MOS
MICROPROCESSORS . . . . 2 YRS
DSP . . . . 3 YRS
PLD . . . . 1 YR
LINEAR INTERFACES . . . . 8 YRS
GATE ARRAYS . . . . 2 YRS

New Technology Generation every 3 and a half years for an average digital design

Low Voltage Digital Technologies Are Projected To Last An Average Of 12 To 15 Years. This Would Include All 3V, 2V and 1V Or Less.
SOURCE: TACTech, Inc.

System Life Cycle is 50 years (or more)

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Figure 1 - Typical Aircraft Program and Semiconductor Life Cycles

To analyze the task at hand we have to have a look at the life cycles of both, our advanced weapon systems and the microelectronics driving it. Figure 1[i] clearly illustrates the conflict we are in.

Whereas the life cycles of our weapon systems have become increasingly longer and exceed in many cases 50 years, the introduction cycles of new commercial microelectronics families average approximately 2 to 4 years, for memory devices they are as short as 9 months. And the trend is continuing.
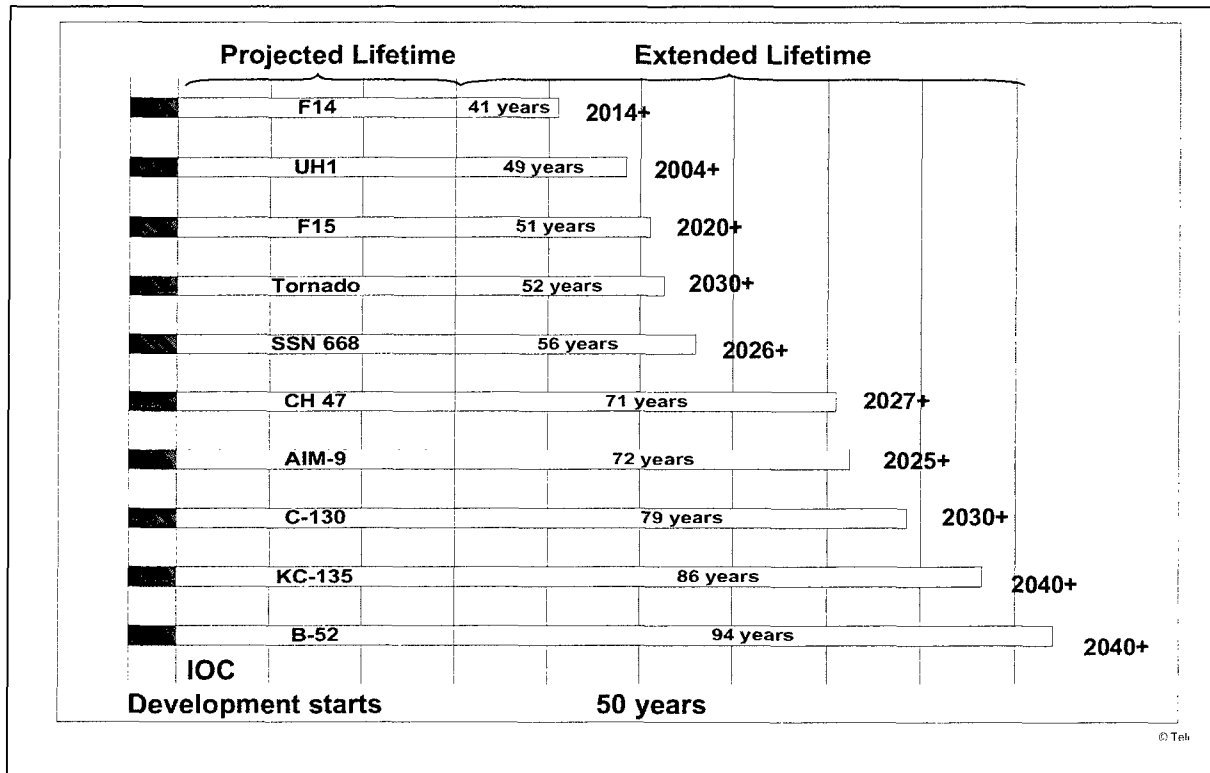
Figure 2 – Weapon System Life Cycles

Figure 2 shows the expected life cycles for selected weapon systems [ii]. If we look at these figures and on the other hand at the life cycles of the semiconductor devices driving our equipment, it becomes apparent, that we have to deal with a very complicated situation.

Leaving the technical aspect aside for a moment, what does this mean to our business? It clearly shows, that our nice and shiny high tech equipment developed today, introduced into service in 3 to 4 years time or even later depending on the weapon system, will become unsupportable in 2010 or even earlier. We will simply not be able to procure the necessary parts for production and more important for product support regardless whether we rely on commercial or military components. The only difference will be, that with the use of commercial components, our problems will materialize earlier because of the shorter life cycles. We all know the sarcastic definition of obsolescence with respect to military equipment:

If it's in production, it's obsolete,

or even worse:

Once it's in production, it's obsolete

Yes of course, the industry has developed crutches to survive in this unpleasant environment, namely

- To make last time, life time or bridge buys to protect production programs and to support products through the later part of their life cycle. All three prone to error and are the antithesis to modern business strategies. They create inventory which may never be used and may finally have to be scrapped.
- To purchase parts from aftermarket suppliers – at a cost
- To search for surplus inventory using professional services such as partsbase.com, GSX, LoKtor or others for product support

But whatever we do, there is no basic difference in the employed processes, commercial part or military, the effort and the results are in general the same and the described options are really only crutches.

Let me tell you about the cruelties of the obsolescence world. A few years ago, we were notified by an ASIC manufacturer, that the production process of one of our ASICs was going to be obsoleted shortly and that we could place a last time buy order, which was what we did. Since we were not in urgent need for the parts, we asked the supplier to store the dies for us. When we finally retrieved the dies from the nitrogen and wanted them packaged, we discovered , that in the meantime the package had become obsolete as well, making a complete re-layout of the respective CCA necessary. Now you may say, that a top notch ASIC supplier would take care of that. Yes, you are right, but we learned the hard way that you cannot buy insurance.

In another case, we were notified by a distributor, that a critical part had become obsolescent, and that we had exactly 6 working days to place our last time buy order. To make it worse, the notification arrived on Dec. 15th with many people already gone for season vacation. We should also bear in mind, that decisions on last time buys and bridge buys need some careful considerations with respect to product support and it is usual practice to agree such buys with the customer, unless we are prepared to accept the full commercial risk. It also clearly illustrates, that the issue of last time buy notifications is a process, which is not very disciplined, and it is to be expected, that it is even less disciplined with commercial components (figure 3 [iii]).

Obsolescence Notification

❏ **Military Components:**
  ➢ **Registered letter to direct customers buying within 5 years**
  ➢ **6 months order entry**
  ➢ **GIDEP**
  ➢ **WEB**
❏ **Commercial Components:**
  ➢ **Letter to direct customers buying within 2 years**
  ➢ **3 months order entry**
❏ **No notification to distribution customers !**
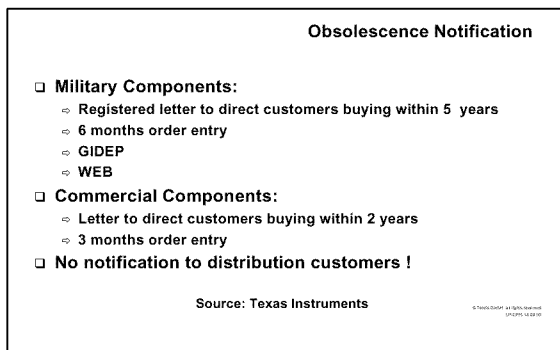
Source: Texas Instruments

Figure 3 - Obsolescence Notification

Since then we have improved our obsolescence management considerably, with the result, that we have much better visibility today. Nevertheless, the obsolescence problems still have to be resolved one way or the other. We do have better diagnostic tools today, but there is still a very sick patient out there and no adequate therapy for a final cure.

But let me get back to my initial thesis. Is the attempt to mitigate obsolescence by the use of commercial components a contradiction in itself?

As we all know, the use of commercial components in military equipment creates its own set of problems as outlined in figure 4.
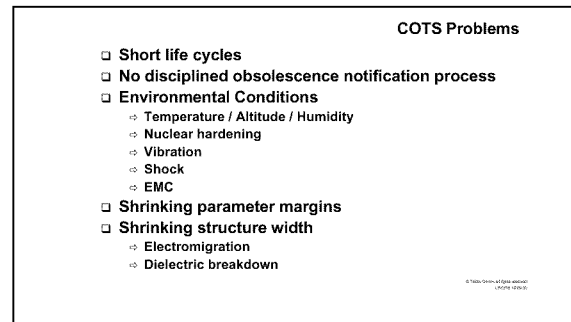

COTS Problems

❏ **Short life cycles**
❏ **No disciplined obsolescence notification process**
❏ **Environmental Conditions**
  ➢ **Temperature / Altitude / Humidity**
  ➢ **Nuclear hardening**
  ➢ **Vibration**
  ➢ **Shock**
  ➢ **EMC**
❏ **Shrinking parameter margins**
❏ **Shrinking structure width**
  ➢ **Electromigration**
  ➢ **Dielectric breakdown**

Figure 4 - COTS Problems

We have to deal with extreme environmental conditions like high and low temperature, gun fire vibration, shock and sometimes nuclear hardening – just to mention a few. In some cases we have to drive the devices outside the specified performance envelope with the risk of unexpected and unknown side effects.

In other cases the performance envelope of the component may not even be specified, for example Nuclear Hardness. In other cases again we may decide to up-rate our devices, which is in itself a highly disputed practice. The up-raters claim, that this is the only way to happiness whereas the semiconductor industry strictly opposes this practice with good reasoning.

The use of Commercial Off The Shelf items or COTS in military equipment has been sparked off by the **PERRY DIRECTIVE** in 1994. Some of Dr. Perry's original wording is given figure 5.

After careful analysis of the text we can extract 4 major objectives, which are:

1. Quote *... that we're going to rely on performance standards instead of relying on mil specs to tell our contractors how to build something ...* unquote.
2. Each system is to use the lowest grade of component, that would meet the environmental and performance requirement of the system,

Figure 5 - Perry Directive

"... We are going to rely on performance standards .... Instead of relying on mil specs to tell our contractors how to build something .... There will still, of course, be situations where we will need to spell out how we want things to be built in detail. In those cases, we will not rely on mil specs but rather on industrial specifications... In those situations where there are no acceptable industrial specifications, or for some reason they are not effective, then the use of mil specs will be authorized as a last resort, but it will require a special waiver."

Secretary of Defense William J.Perry, press conference June 29, 1994

3. Mil specs and standards should only be used as a last resort
4. Remove requirements, which do not add value.

The Perry Directive is one of the most misunderstood and misinterpreted directives in our business. When you read it, you know why, since there is a lot of room for misinterpretation. It does not say we must use commercial components and it does not say, that all military specification are void either.

In the wake of the Perry Directive our customers increasingly insist on the use of COTS to keep up with the edge of technology and concurrently reduce cost. At the same time industry is faced with the problem, that despite all the encouragement to make extensive use of COTS the necessary relaxation of the associated implementation requirements in our specifications - how we have to build something as Dr. Perry has put it - have not yet come along. In addition we still have to meet the tough environmental requirements already mentioned regardless of the Perry Directive. As a consequence the industry ends up between the rock and the hard place and has to accept a high technical and commercial risk when acquiring defense contracts. This situation is further complicated by the customer's – legitimate? - expectation, that due to the use of commercial components, the equipment acquisition and support cost should drop significantly.

All this is happening in an environment of steadily diminishing supply of military components, and rapid innovation cycles for commercial component families, without leaving any significant purchasing power for the equipment supplier industry in a market, which is primarily driven by telecommunication, the internet and PC industries and consumer electronics. Figure 6 illustrates the semiconductor market as of 1999 [iv].

In a press release[v] the Semiconductor Industry Association announced in February a worldwide semiconductor sales figure of 149 billion US dollars for 1999, which was an all time record. In the same press release an expected growth in excess of 20 % for 2000 and 2001 was announced. And the SIA June figures[vi] clearly confirm this trend with an actual growth of 48.1 % over the 1999 figures (figure 7).

The drivers for the semiconductor industry are changing rapidly from the PC industry to the telecom and internet appliances.
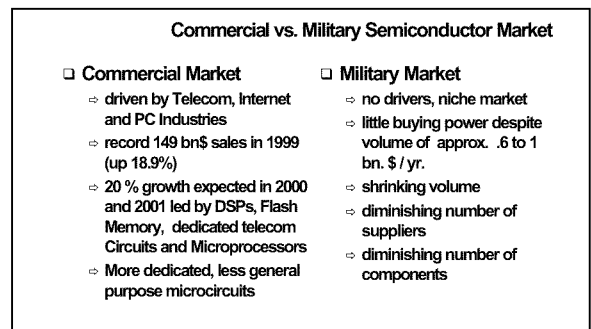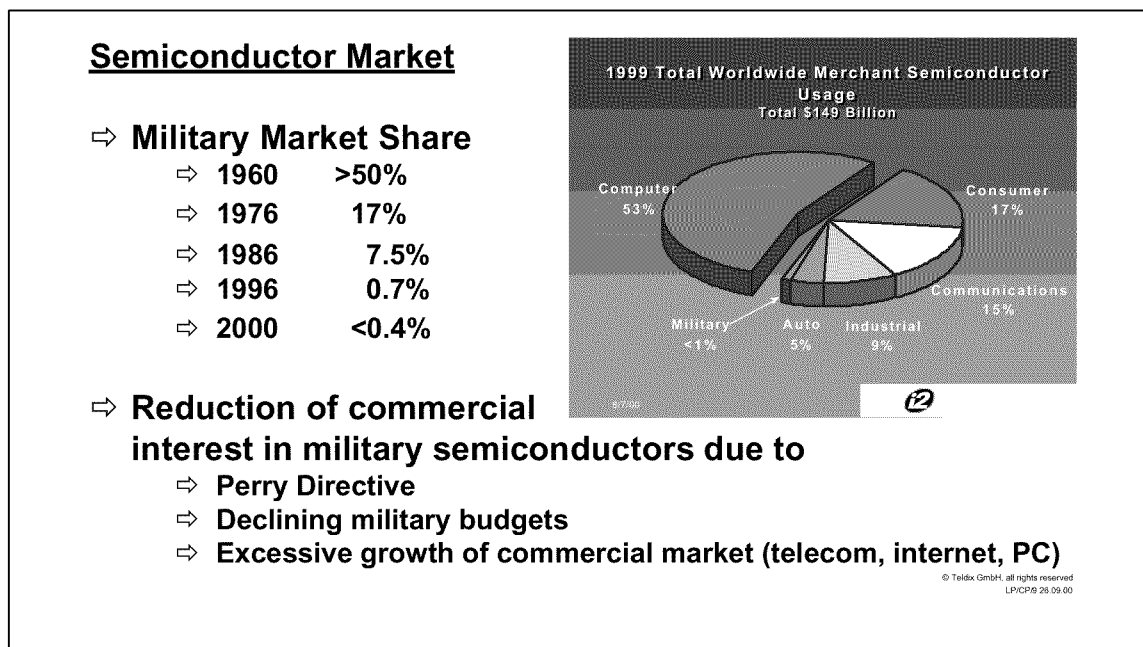

Figure 7 - Commercial and Military Semiconductor Market

Figure 6 - Semiconductor Market

While in 1999 approximately 200 million cell phones were sold, the SIA is expecting a market volume of one billion cell phones in 2003[vii] quintupling the market volume in four years. What significance has the continuously shrinking military semiconductor market of 600 million to 1 bn US $ / yr. in this context despite the volume in itself being impressive?

To summarize let's have a look at the different drivers for obsolescence and the use of COTS on the other side. It appears, that both issues have little in common, except for market factors. The use of COTS is mainly commercially driven, whereas obsolescence is basically technology driven, and is applicable to COTS as well. (figure 8)
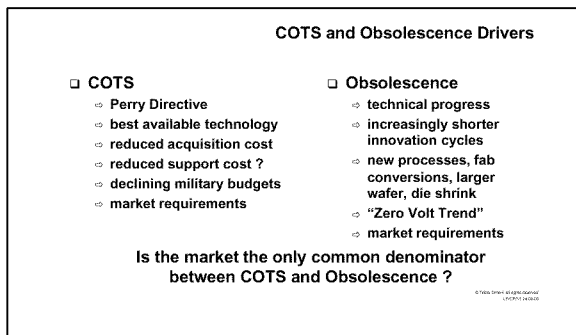
COTS and Obsolescence Drivers	
❑ **COTS**	❑ **Obsolescence**
⇨ Perry Directive	⇨ technical progress
⇨ best available technology	⇨ increasingly shorter innovation cycles
⇨ reduced acquisition cost	⇨ new processes, fab conversions, larger wafer, die shrink
⇨ reduced support cost ?	
⇨ declining military budgets	⇨ "Zero Volt Trend"
⇨ market requirements	⇨ market requirements
Is the market the only common denominator between COTS and Obsolescence ?	

Figure 8 - COTS and Obsolescence Drivers

As a result my first and rather trivial theorem is:

> ***Commercial components are not a solution to the obsolescence problem, they are part of the problem.***

But still, what is the solution to our Obsolescence problem?

Let's get back to Dr. Perry for a while, does he help us with our problem? What do the four objectives identified earlier really mean with respect to our obsolescence problem?

As we remember, Dr. Perry's first objective was:

Use performance based specs.

What does that mean?

A first step on our way to deal more effectively with obsolescence may be the adoption of a black box approach for our equipment, similar to the practice in the civil aviation community. That means, that the specification defines only the required performance, the environmental conditions and the interfaces, but no implementation details. What is inside the box should be left to the supplier. That includes bold concepts like technology transparency and technology insertion for the

equipment in question, with the result of having different build standards for the same specification, all of which will satisfy the specification in all aspects. Yes, I agree, there are lots of arguments not to do this, such as qualification and re-qualification problems, support, configuration issues, customer software and other problems as listed in figure 9.
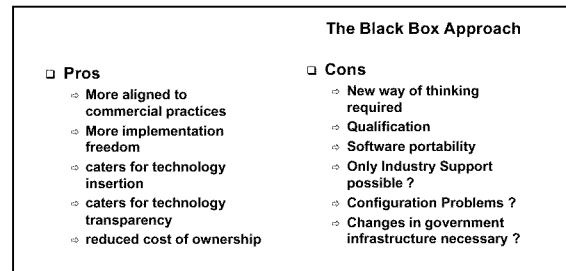
The Black Box Approach	
❑ **Pros**	❑ **Cons**
⇨ More aligned to commercial practices	⇨ New way of thinking required
⇨ More implementation freedom	⇨ Qualification
⇨ caters for technology insertion	⇨ Software portability
⇨ caters for technology transparency	⇨ Only Industry Support possible ?
⇨ reduced cost of ownership	⇨ Configuration Problems ?
	⇨ Changes in government infrastructure necessary ?

Figure 9 - The Black Box Approach

This does not mean, it cannot be done, it just means that we have to be more creative in the future in dealing with these issues. This will require close cooperation of all involved parties from government to industry. As to our obsolescence problem, the industry might be able to compensate some obsolescence non recurring cost with recurring savings which may become possible by value engineering and the use of more advanced technology throughout the life cycle of the equipment. Here we may be able to learn something from the civil aviation. They must have a very similar set of problems, how do they cope with them?

Dr. Perry's second objective was:

Each system is to use the lowest grade of component, that would meet the environmental and performance requirement of the system.

This objective amends nicely what has been said for objective number 1. It will remove the requirement to use the highest quality grade of components, freeing the industry to select the quality level it sees fit to fulfill the specification. This will most likely have a positive impact on cost, but will not help much with our obsolescence problem.

Dr. Perry's third objective was:

Mil specs and standards should only be used as a last resort.

I am under the impression, that this objective has gone totally unnoticed within our customer community, at least in Europe. How nice would it be, if we wouldn't have to read a hundred or more mil specs with every RfQ.

Instead I find more and more mil specs in the requirements which have officially been cancelled already or which are totally irrelevant, nevertheless being a diligent program manager, I have to comply somehow and read all of it.

However, the objective in itself is a good one and we should all work hard, to enlighten our customers, that less may be more.

Now some may say: "What do I care about the Perry Directive, I am here in Europe and have nothing to do with the US Government Acquisition practices". This may be true, nevertheless I personally think, this is a rather ridiculous argument, since we did not hesitate at all to accept the excellent system of mil specs and standards during the cold war. Now, as the US DoD relies more and more on COTS and has started to send mil specs and standards into retirement, we Europeans won't let go.

Dr. Perry's fourth objective was:

to remove requirements, which do not add value.

In my humble opinion this is simply common sense, although this - as number 3 above - has apparently gone unnoticed by our customers. Everyone in the industry familiar with government acquisition processes must have asked himself over and over again: " why the hell do they want this". In many cases the answer is simple: It was somewhere in the model text the author has used to compile the specifications or the request for quotation.

Again, the removal of non value adding requirements is a great concept and would alleviate many problems in fielding new equipment, it may also help to reduce cost and time to market, it will, however, not help to battle obsolescence.

That leaves us with objective number one, the black box approach and the adoption of civil procedures. What other options do we have to alleviate the problem? One way that has been generally accepted in many defense programs, is to align the removal of obsolescence with planned weapon system upgrades. In order to enable the industry to do that, a much better visibility as to the planned upgrade path of the weapon system has to be provided. This again requires very close cooperation between government, Weapon System Contractor and supplier industry.

I have to admit, this might only be a first small step and is still far from being a technical solution. And we need more than that. We have to have both, a stable and sound technical as well as a commercially viable business solution. We need, however, to start somewhere.

In my effort to prepare this paper I searched the internet for information on the subject and to my surprise I found plenty of information out there. Actually it was much more information than I was able to digest in the limited period of time. In the US alone I found more than 100 web sites and 34 different projects dealing with the obsolescence problem, most of them sponsored by the DoD or the services. In addition there are dedicated DMSMS program organizations or management teams in place to deal with obsolescence for a specific weapon system such as for the B2 Bomber. Much work has been done in this field by the US Air Force Materiel Command, the Defense Logistic Agency (DLA), the Defense Microelectronics Activity (DMEA), the Government Industry Data Exchange Program (GIDEP), the Generalized Emulation of Microcircuits activity (GEM) but also by private enterprises such as TacTech now I2 and others. None of these activities is trying to solve the obsolescence problem once and for all since there is no such solution. All activities are geared to defining and providing tool sets to handle obsolescence problems as they occur.

What can be learned from these activities, which again are all located in the US, is, that we need to approach the problem on a much higher level, with all entities involved, be it industry or government, working much more closely together to keep the problem under control. The progress made in the US is in my opinion mostly to be attributed to the fact, that the Department of Defense and the services with their organizations have recognized very early the grim facts of obsolescence and have proactively promoted a variety of activities to jointly overcome the problem, instead of making obsolescence simply a problem or even a liability of the equipment supplier industry. When we review what has been achieved in the US already, I feel, there is a lot of work – and education - to be done in Europe to catch up. And in doing so, we should accept the experience of others instead of re-inventing the wheel. Are there already answers available, which we do not use, simply because we do not know about them?

The way we are presently trying to manage obsolescence is bottom up, everyone solves his little problem in his little box which means the same problem is being solved over and over again. We have to come up with a top down approach to be more efficient. This requires bold moves and the implementation of what I call "wild ideas" as shown in figure 10. May be some of those ideas are not so wild at all, but someone has to take the lead, and this cannot be the supplier industry. Again, what we need is a top down approach.

And beyond this?

Wild Ideas.....

.....or not so wild at all
- ⇨ Cross Corporation Obsolescence Management
- ⇨ Joint Purchasing and Warehousing
- ⇨ Shared Data Warehouse
- ⇨ Weapon System Coalitions to battle Obsolescence (e.g..teaming of F16, C17, B1-B, JTIDS, MILSTARS, AWACS and JointSTARS in the USAF)
- ⇨ Is a NATO Obsolescence Management Organization too long a shot ???
- ⇨ Can we get help somewhere else, use the experience of others?
- ⇨ There is plenty of information and experience out there, we just have to go get it (and use it).
- ⇨ Who is taking the lead ???

Figure 10 - Wild Ideas

But let me come back to the question of using commercial components in military equipment. As I have outlined already, the use of COTS components is in my opinion no way to mitigate the obsolescence problem, since COTS is subject to obsolescence itself, and as we are all aware, life cycles are shorter and the obsolescence notification process is less disciplined. No matter what, the supplier industry will be forced to make more and more use of commercial components simply because of the continual erosion of the supply base of military components. We will have to deal with even more difficult obsolescence problems in the future. In addition it must be said, that the trend towards commercial components is not limited to the battle between plastic versus ceramic packages. The use of COTS components in military applications may create an additional set of problems in the future which may for instance be attributed to the consistently shrinking structure width of microcircuits as a result of the demand from the telecom industry and the trend towards zero volt supply voltage. This may result in tremendous EMC problems for our equipment.

But isn't the controversy between military and commercial a controversy between extremes. There is not only black and white, there are shades of gray as well. Within the last 10 years QML has gained a lot of attention and importance within the defense industry. Many of the big names, who dropped out of the military semiconductor business, have certified their production lines to meet the QML requirements. Today more than 30 semiconductor manufacturers have qualified more than 300 production lines and the trend shows a stable growth. In short QML is not just commercial, but is simply better. Actually QML is best commercial practice. It is more expensive than "commercial", but is more disciplined, it meets most of our stringent requirements for military equipment and it has longer life cycles. However, QML is vulnerable to obsolescence as well, and the use of QML does not solve our obsolescence problem either.

And here comes my second theorem, which is rather trivial again:

Although the use of commercial components does not help to mitigate the obsolescence problem, we have to use them anyway to mitigate the eroding supply base of military components.

All in all the use of commercial components in our military systems is - as mentioned before – still a big problem in itself. It requires more research, diligence, cooperation, and a lot of common sense. QML may help - as long as it lasts.

On the other hand, obsolescence management is – as we have all become painfully aware – a tremendous task in itself, requiring its own infrastructure and resources. And it has to be done regardless of the component quality level.

Summary

- ❑ The use of Industrial Grade Components in military equipment will become a necessity, due to the diminishing supply base for military components

- ❑ The use of Industrial Grade Components is not a way to mitigate obsolescence problems ... to the contrary

- ❑ The use of Industrial Grade Components is an additional challenge to obsolescence management, which has to be accepted by the industry.

Figure 11 - Summary

In summary my conclusion is, that in the long run the use of commercial components in our systems will become a necessity but for other reasons. It is not a way to mitigate obsolescence, it is an *additional* challenge to obsolescence management. Still, there is no other way than to accept this challenge, since our military semiconductor supply base will continue to erode.

About the Author:

The Author is a German national and holds degrees in electronic engineering and business administration and has more than 30 years of international experience in the defence industry. Prior to joining TELDIX he held various program / project management positions at LITEF, Litton Aero Products, AEG and DASA. He joined TELDIX GmbH, an affiliate of Litton Industries in Germany, in 1990 where he is today Head of Program Management and responsible for all defence programs. In his function he is extensively involved in the company's Eurofighter Typhoon Business.

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[i] Graphics with friendly permission of TacTech / i2
[ii] Concept Paper: Virtual Parts Supply Base, 15. Jan. 1998
[iii] Texas Instruments
[iv] Graphics with friendly permission of TacTech / i2
[v] The Semiconductor Industry Association, 9. Febr. 2000
[vi] The Semiconductor Industry Association, 3.Aug.2000